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ABE Farm Door Automation

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Problem Statement

The Hydroswing door for large equipment access to the south end of the Harvest Storage and Transportation building requires manual operation through the entirety of the open/close cycle. The operation of the door has risks concerning the safety of people and equipment. The door must have a safety device in place to make sure there is no equipment or personal in the way while closing.

o The client is an entity of Iowa State University located on the ISU BioCentury Research Farm.

o Manually operating the door creates wasted time because it requires a person to stand by the button for about five minutes while the door is in operation.

o Automating the door would allow the client to open the door by simply pressing a button, allowing the operator of the door to be able to carry out another task, examples would be preparing or moving equipment, while the door is running.

o There is a safety concern with the door being hydraulic; it will cause damage to anything in the path of the door while in operation.

o This problem is common among Hydroswing doors. They are common with aircraft hangers and other commercial buildings that need a large door for moving equipment in and out of the building.

o The solution can be implemented to other doors that are similar in design.

Disciplines

Bioresource and Agricultural Engineering | Industrial Technology

Authors

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Department of Agricultural and Biosystems Engineering (ABE)

TSM 416 Technology Capstone Project

ABE Farm Door Automation

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Client: BioCentury Research Farm, 1327 U Ave, Boone, IA, 50036, https://www.biocenturyresearchfarm.iastate.edu/

- Contact(s): Robert Hartmann, Program Coordinator, rchartma@iastate.edu, 515-294-4824; Karl Moritz, Program Coordinator, kjmoritz@iastate.edu, 515-294-4848.

1 PROBLEM STATEMENT

The Hydroswing door for large equipment access to the south end of the Harvest Storage and Transportation building requires manual operation through the entirety of the open/close cycle. The operation of the door has risks concerning the safety of people and equipment. The door must have a safety device in place to make sure there is no equipment or personal in the way while closing.

Problem Statement

- The client is an entity of Iowa State University located on the ISU BioCentury Research Farm.
- Manually operating the door creates wasted time because it requires a person to stand by the button for about five minutes while the door is in operation.
- Automating the door would allow the client to open the door by simply pressing a button, allowing the operator of the door to be able to carry out another task, examples would be preparing or moving equipment, while the door is running.
- There is a safety concern with the door being hydraulic; it will cause damage to anything in the path of the door while in operation.

- This problem is common among Hydroswing doors. They are common with aircraft hangers and other commercial buildings that need a large door for moving equipment in and out of the building.
- The solution can be implemented to other doors that are similar in design.

Business Case Statement – The current system is slow and wastes valuable time for the client. This creates an opportunity to reduce costs and wasted efforts, as well as include additional safety measures.

2 MAIN OBJECTIVE

- **Goal Statement:**

A. The root cause of the problem was identified as: the current design of the door controls not allowing for automated operation.

B. The process will be measured by proof that the design will allow for automated poka-yoke operation, meaning the system is fault-proof, simple, and reliable.

- **Main Objective(s) and Specific Objectives**

  The main objective is to use brand-name components to create high quality, efficient remote door operation system to save several minutes waiting on the door to open and close. Specific objectives include:

  Designing an electrical system that allows for remote door operation.
  - Use photo eye sensors to detect any interference with the door operation.
  - Use limit switches to automatically stop the door when it is fully open or closed.
  - Use a remote which runs the door with a single push of the button.
  - The system cost is $1000 or less.
  - The system is poka-yoked.
  - The system is reliable and can withstand harsh seasonal conditions.
- **Rationale**
  - Reduced waiting time when entering/exiting the building with tractors, combines, and trucks.
  - Increased operator safety when operating the door.
- **Project Scope**
  - Develop two possible solutions that the client will then be able to decide which solution they feel will work best for their system.
  - We have narrowed our scope to supply two options, and proof-of-concept, rather than physically retrofitting the door.
  - Our proof-of-concept includes a design on an electrical design program called Logix Pro.

3 METHODS/APPROACH

A. Methods/Approach

- **Reference Material(s):**
  - Door manufacturer websites were researched, in-person meetings and conference calls were conducted with the client, and the door manufacturer, Schweiss Doors, was contacted by email for support.
- **Data collection**:
  - Door dimensions: length and height; type of door: hydraulic motor, swinging movement; all serial numbers and part numbers provided to the door manufacturer, constraints and criteria for the project were gathered by an on-site inspection; simulation: PLC programming for the door system was simulated on a computer using programming software.

- **Skills**:
  - Professional communication skills to contact parts, suppliers, and clients.
  - Mechanical expertise to have a grasp on issues or unthought-of features that may be included in the project.
  - Automation design, programming, and using simulation software.
- **Solutions**:
  - The ability of the proposed solution to satisfy project requirements
  - Overall, the design of the door would fulfill the requirements of the customer
  - The door would also operate safely with the correct components
- **Organization:**
  - Email contact with the client and parts supplier weekly
  - Biweekly conference calls with the client
  - Capstone group message with all group members to facilitate communication

4 RESULTS

Results/Deliverables

- The main deliverable was to provide two options available to automate the door operation with the touch of a button. As a result of delivering that, an internal design was created and proposed.
- The door's operation must allow for safe and poka-yoke operation.
- The door must provide safe opening and closing procedures to accommodate all possible types of traffic that could pass through the system.
- Our solutions and our simulation should leave the client with a good understanding of how the two systems work, as well as the differences between the two.
- The solution should produce a return on investment; this will occur through time efficiency, safety, and overall ease of door operation.

Recommendations

- Use the name brand solution from Schweiss Doors to satisfy the necessary reliability and safety.
- Decision Matrix showing our recommendation (OEM Solution) located in appendix
- The client is to install the system themselves, reducing cost, and streamlining the project.
- Purchase the light and siren components separately to reduce costs.
- The client is to install all components as indicated in the wiring and relay diagrams that be found in the appendix.

5 BROADER OPPORTUNITY STATEMENT

This opportunity does not only apply to the problem that our client has but also applies to other consumers, and businesses have similar doors.

- The project solution would apply to a wide variety in the industry because it is simple wiring with sensors and limit switches.
- The project ideas could be applied across other commercial doors and manufacturing from the concept of creating a more lean process. The purpose of this project is to make the facility more easily accessible for the operators and reduce wasted time.
- This problem is experienced by anyone that has a similar commercial door or a door that is operated manually. These doors are common in agriculture, manufacturing, and airplane hangars.

- The current way the door operates is common, and many doors operate the same way. The manufacturer of the door offers all the upgrades needed to create an automatic door.
- Eliminating this problem would help reduce waiting time from the operator and would eliminate the need for the operator to stand by the opener and hold the button.

6 GRAPHICAL ABSTRACT

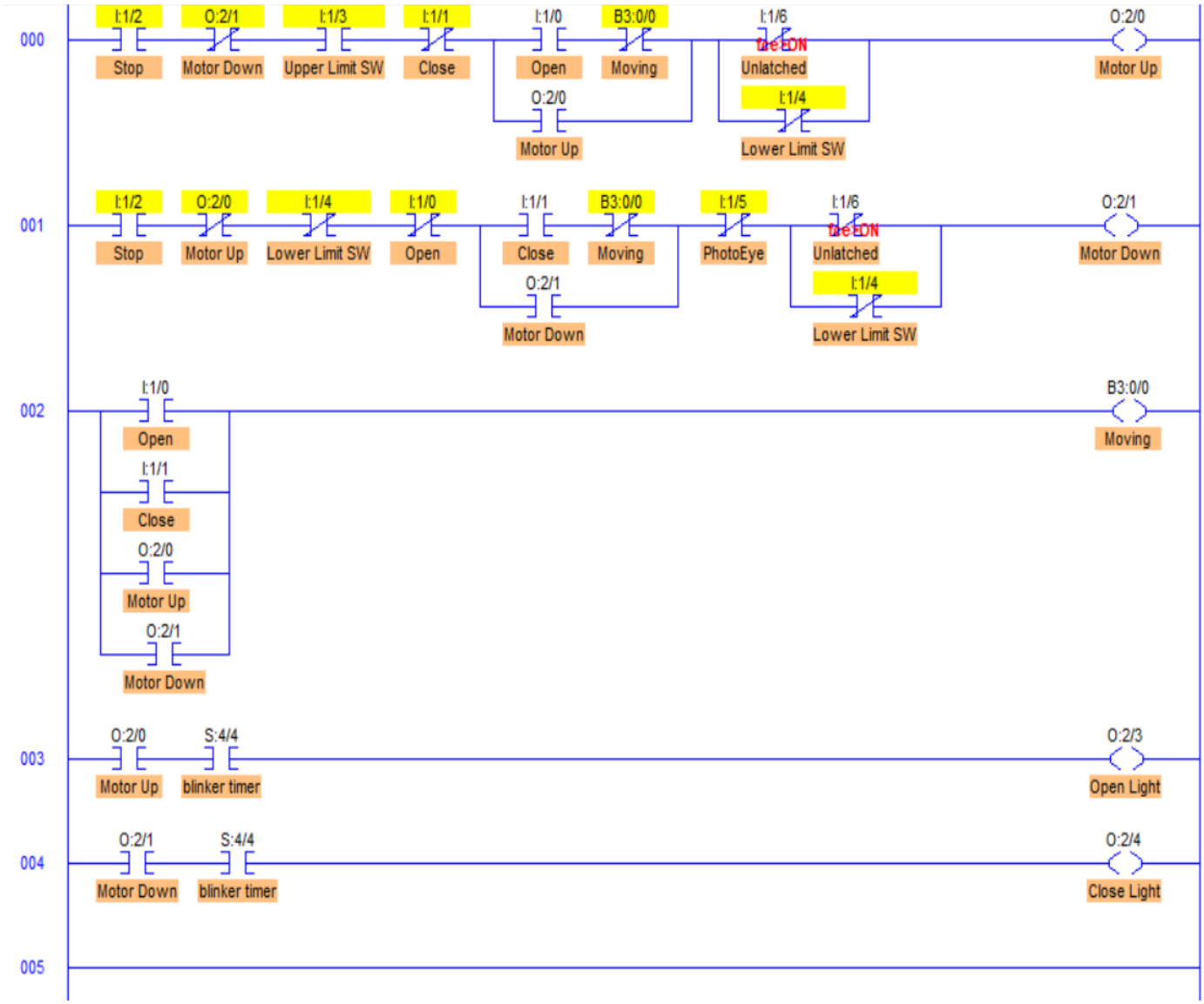


Image depicting the relay ladder logic (electronic circuitry logic) utilized to operate the automated door controls in a simulated computer environment.

7 REFERENCES

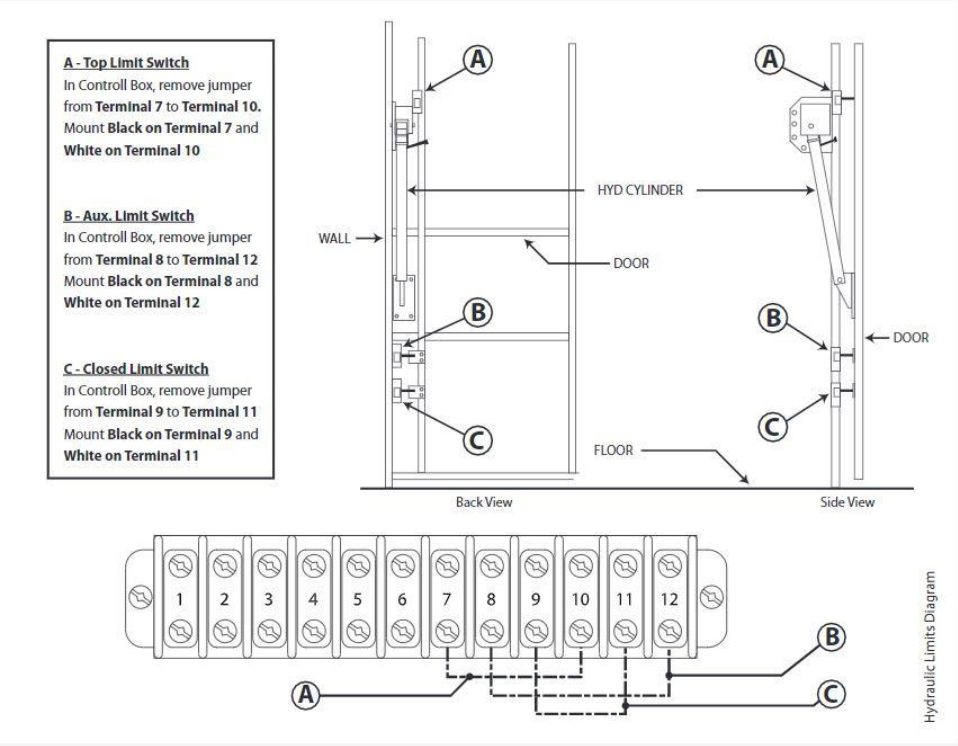
Beacon rotating light, 86mm yellow lens, Stud mount, Incandescent bulb, 24V AC/DC 8W. (n.d.). Retrieved from https://shop.industrialemart.com/index.php?route=product/product&path=59&product_id=4215

High-Profile Amber LED Permanent Mount Forklift Strobe Light - 12 to 110 Volts. (n.d.). Retrieved from https://www.globalindustrial.com/p/material-handling/forklifts-attachments/forklift-lights/high-profile-amber-led-permanent-mount-forkli-strobe-light-12-to-110-volts?infoParam.campaignId=T9F&gclid=EAIaIQobChMImoehv-2w5gIVx0XVCh2U1g3oEAQYASABEgLRKfD_BwE

SCHWEISS: WORLDWIDE DOOR SALES. (n.d.). Retrieved from https://www.bifold.com/note-hydraulic.php

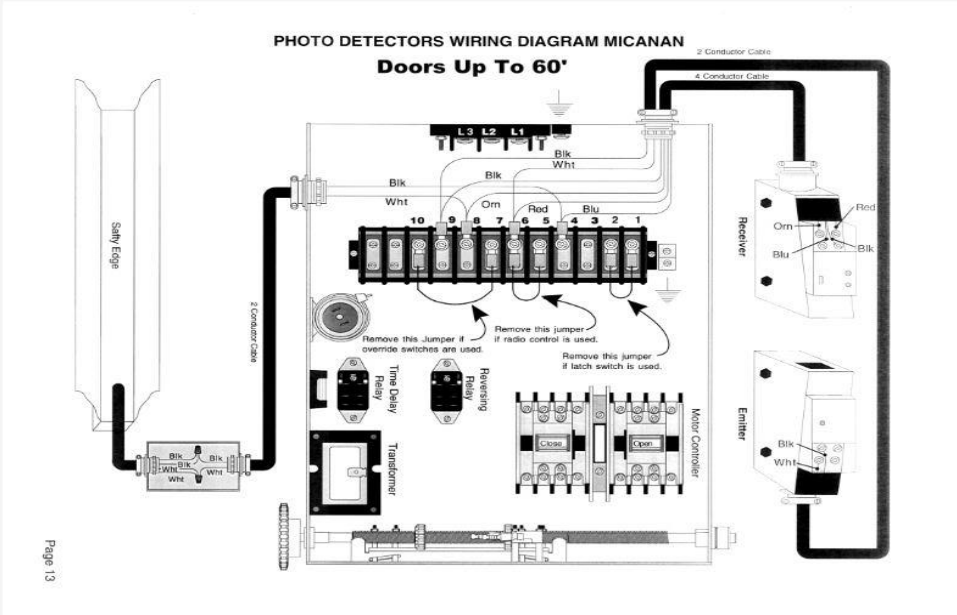
Strobe Light and Horn. (n.d.). Retrieved from https://signalguys.com/Strobe-Light-and-Horn-490SMT4_p_678.html

8 APPENDIXES

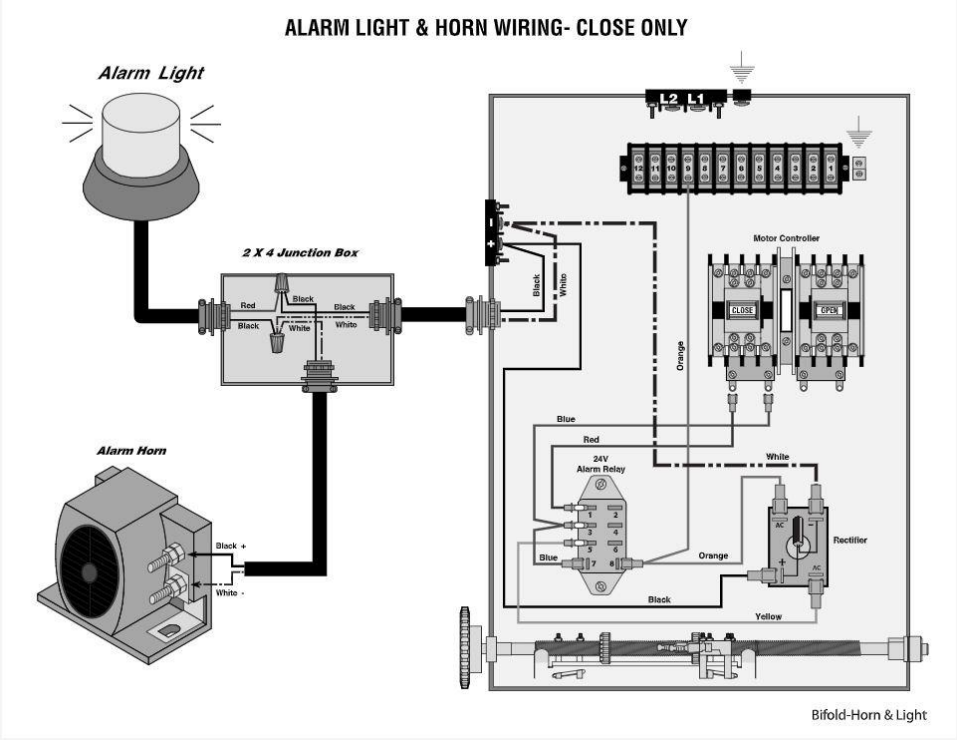


Above: image depicting the location of limit switches labeled A, B and C

on the swinging door and frame, as well as the terminals that the switches connect to electrically.



Relay box wiring diagram which depicts the electrical connections
to power the photo eye sensors



Relay box wiring diagram showing electronic circuits to power the light (top left of image) and siren (bottom left of image)

Milestone Performance				
Work Breakdown Structure		Summary/Measurble	Verification Date	On / Off Schedule
1.0	**Define project needs and details**			
1.1	define project needs		11/4/2019	on
1.1.1	constraints		11/4/2019	on
1.2	define purchases needs		11/15/2019	on
1.2.1	concept design		11/15/2019	on
1.2.2	design approval		11/20/2019	on
2.0	order materials			
2.1	define what we need		11/23/2019	on
2.1.1	get a list of whats already availible		12/20/2019	on
3.0	Install sytstem			
3.1	fabrication		3/1/2020	on
3.1.1	install		3/1/2020	on
3.1.2	test		3/15/2020	on

Timeline of the project

% Weight	Criteria	Name Brand OEM	Rating (Weight*Criteria)
20%	Cost	1	0.2
40%	Safety	3	1.2
30%	Reliability	5	1.5
10%	Install/Support	3	0.3
	Total:		3.2
% Weight	**Criteria**	**Custom Design**	**Rating (Weight*Criteria)**
20%	Cost	3	0.6
40%	Safety	1	0.4
30%	Reliability	3	0.9
10%	Install/Support	1	0.1
	Total:		2

Decision matrix